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भारतीय मानक

11/12 GHz बैंड में उपग्रह प्रसारण प्रेषण के लिए अभिग्राही एंटीना

भाग 1 विद्युतीय मापन

(पहला पुनरीक्षण)

Indian Standard

RECEIVING ANTENNAS FOR SATELLITE BROADCAST TRANSMISSIONS IN THE 11/12 GHz BAND

PART 1 ELECTRICAL MEASUREMENTS

(First Revision)

ICS 33.060.20

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

August 2012 **Price Group 13**

Audio, Video and Multimedia Systems and Equipments Sectional Committee, LITD 07

NATIONAL FOREWORD

This Indian Standard (Part 1) (First Revision) which is identical with IEC 61114-1 : 1999 ‘Receiving antennas for satellite broadcast transmissions in the 11/12 GHz band — Part 1: Electrical measurements’ issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Audio, Video and Multimedia Systems and Equipments Sectional Committee and approval of the Electronics and Information Technology Division Council.

This standard was originally published in 1994 which was identical to IEC 61114-1 : 1992 and has now been revised to align it with the latest version of IEC 61114-1 : 1999.

The text of IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words ‘International Standard’ appear referring to this standard, they should be read as ‘Indian Standard’.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60050 (712) : 1992 International Electrotechnical Vocabulary (IEV) — Chapter 712 Antennas	IS 1885 (Part 21/Sec 1 to 6) : 1988 Electrotechnical vocabulary: Part 21 Antennas, Section 1 Basic terms for antennas and antennas assemblies Section 2 Terms related to electrical or radiating characteristics of antennas Section 3 Terms related to types of antennas defined by their electrical or radiating characteristics Section 4 Terms related to antennas and antennas elements consisting mainly of radiating conductors Section 5 Terms related to antennas and antennas elements consisting mainly of radiating surfaces and apertures Section 6 Terms related to devices associated with antennas	Technically Equivalent

(*Continued on third cover*)

Indian Standard

RECEIVING ANTENNAS FOR SATELLITE BROADCAST TRANSMISSIONS IN THE 11/12 GHz BAND

PART 1 ELECTRICAL MEASUREMENTS

(First Revision)

1 Scope

This part of IEC 61114 applies to individual and collective receiving antennas for satellite broadcast transmissions in the 11/12 GHz band.

This standard mainly applies to paraboloidal reflector antennas, which include offset paraboloidal reflector antennas, Cassegrain reflector antennas and other equivalent types. It also applies to planar array antennas. However, the supporting mast and the radome are not included in this standard.

This standard applies to the following six types of antennas.

a) Antenna of a single antenna system to receive signals from a single satellite
   1) linearly polarized single-beam antenna;
   2) circularly polarized single-beam antenna.

b) Antenna of a single antenna system to receive signals from two or more than two satellites
   1) linearly polarized multiple beam antenna;
   2) circularly polarized multiple beam antenna.

c) Antenna of a multiple antenna system to receive signals from two or more than two satellites
   1) linearly polarized system of single-beam antenna;
   2) circularly polarized system of single-beam antenna.

Typical configurations of these six types are illustrated in figure 1.

The object of this part of IEC 61114 is to define the conditions and methods of measurement to be applied. This standard does not specify performance requirements.

It is assumed that for some measurements the SHF converter will be removed from the antenna, leaving access to an r.f. port.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61114. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and the parties to agreement based on this part of IEC 61114 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60050(712):1992, *International Electrotechnical Vocabulary (IEV) – Chapter 712: Antennas*

IEC 61079-1:1992, *Methods of measurement on receivers for satellite broadcast transmissions in the 12 GHz band – Part 1: Radio-frequency measurements on outdoor units*

3 Terms and definitions

For the purpose of this part of IEC 61114, the following general definitions apply.

3.1
receiving antenna
SHF antenna intended for use in individual and collective reception of satellite broadcast signals

A polarization switching device is included in an antenna, if the antenna is able to receive two orthogonal polarized waves.

3.2
paraboloidal reflector antenna
antenna usually comprising main reflector, a primary (and sometimes a secondary) radiator with or without a feedome, an SHF converter, supporting structures for a primary radiator or subreflector and pointing structures

3.3
planar array antenna
antenna usually comprising radiating elements, a feed network, an SHF converter, supporting structures, pointing structures and a radome

3.4
standard antenna
antenna which is used as a gain reference for receiving antennas under test

3.5
source antenna
antenna which is used as a transmitting antenna for measurements

3.6
polarization switcher
device which can select one type of polarization

4 General notes on measurements

4.1 General conditions

4.1.1 Introduction

Measurements should be carried out in accordance with the following conditions to ensure repeatable results.

4.1.2 Testing site

Measurements shall be carried out at a facility where external radio interference and reflections from the ground and from surrounding structures have been minimized and their residual effects have been measured.

The testing site for G/T measurement is provided in 4.3.3.

4.1.3 Power supply

If an SHF converter is used as an integral part of the antenna, a power supply equivalent to the rated voltage of the converter shall be used. The fluctuation of the power supply voltage during tests shall not exceed ±2 %.

4.1.4 Accuracy of measuring instruments

Requirements for the accuracy of measurements are not included in this part of IEC 61114, because they depend only on the purpose for which the measurements are required. The accuracy of the measuring instruments used, if known, shall either be stated as a percentage or in decibels, as appropriate. Alternatively, the precision class may be quoted as stated in relevant publications (under consideration).

4.1.5 Residual standing wave ratio (SWR) of test instruments

The residual SWR of the test instruments shall be less than 1,1 for measuring the antenna gain and the impedance matching, and less than 1,5 for measuring the radiation pattern, the cross-polar pattern and the cross-polarization discrimination.

4.1.6 Stabilization period

Unless otherwise specified, measurements should be started once stabilization of the characteristics is obtained.

4.2 Test signal and test frequencies

Unless otherwise specified, the test signal shall be a c.w. signal and its frequency shall be the lowest, middle and highest frequencies in the 11/12 GHz band as specified by the standard of the country or countries for which the antenna under test was designed.

If there is interference at these frequencies, the test frequency can be shifted slightly to avoid the disturbance.

If the characteristics of the antenna are strongly frequency-dependent, the measurements shall also be carried out at those frequencies where significant changes occur.

4.3 Arrangement of source and receiving antennas

4.3.1 Antenna distance

The distance R between the aperture planes of the source antenna and the antenna under test shall satisfy the following equations:

$$R > 2D_1^2 \ / \ \lambda$$

$$R > D_1 \, D_2 \ / \ 0{,}32 \ \lambda$$

where

D_1 is the largest aperture diameter of the antenna under test, in metres (m);

D_2 is the largest aperture diameter of the source antenna, in metres (m);

λ is the free-space wavelength at the test frequency, in metres (m).

4.3.2 Spatial variation of the field

The spatial variation of the field at the aperture plane of the antenna under test shall be minimized. The variation in the power received from a standard antenna shall be within ±0,5 dB on the aperture plane of the antenna. If the antenna under test is designed to receive two orthogonal circularly polarized waves, the variation shall satisfy the above value for both right- and left-hand circularly polarized waves. If the antenna under test is designed to receive two orthogonal linearly polarized waves, the variation shall satisfy the above value for both horizontal and vertical linearly polarized waves. The method of measurement of the variation is described in 5.1.

If a larger variation is observed, the position and height of the antenna should be changed to obtain the value specified above.

4.3.3 Environmental conditions for G/T measurements

When the measurements of G/T are made (see 5.8), the following conditions shall be maintained:

- the sky shall be clear;
- there shall be no noise sources such as the sun, a satellite, buildings and trees within 10° around the beam axis of the antenna under test.

4.4 Other conditions

If an SHF converter is used, the field intensity at the aperture plane shall be chosen so as not to overload the converter. The overload level of the converter is described in IEC 61079-1.

4.5 Measuring instruments

4.5.1 Circularly polarized standard antennas

A right-hand circularly polarized antenna and a left-hand circularly polarized antenna which have a nominal gain of more than 20 dB shall be provided as standard antennas.

An example of a suitable antenna is described in annex A.

The gain shall be calibrated at the test frequencies.

NOTE – A linearly polarized horn antenna can be used as the standard antenna. However, the accuracy of the gain measurement may be slightly reduced.

4.5.2 Linearly polarized standard antenna

A linearly polarized antenna which has a nominal gain of more than 20 dB shall be provided as the standard antenna. An example of a suitable antenna is described in annex B. The gain shall be calibrated at the test frequencies.

4.5.3 Circularly polarized source antennas

A right-hand circularly polarized antenna and a left-hand circularly polarized antenna shall be provided as the source antennas. These antennas shall have the same nominal characteristics and a cross-polarization discrimination of more than 30 dB.

These values can be confirmed by the standard antenna (see annex C).

4.5.4 Linearly polarized source antenna

A linearly polarized antenna shall be provided as the source antenna. The antenna shall have a cross-polarization discrimination of more than 30 dB.

4.5.5 Variable attenuator

A waveguide type precision attenuator having a variable range of 30 dB with an accuracy of better than ±0,2 dB is required.

If an additional attenuator is introduced to set power at an appropriate level, it is not required to have the above accuracy.

5 Methods of measurement

5.1 Calibration of field intensity

5.1.1 Introduction

Prior to measuring the characteristics of the antenna under test, calibration of the field intensity at the aperture plane of the antenna shall be carried out using a standard antenna. A circularly or linearly polarized standard antenna is used as the standard antenna corresponding to the polarization of the antenna under test.

5.1.2 Method of measurement

The arrangement of the test equipment is shown in figure 2.

The measurement shall be made using the following procedure:

a) set the source antenna and the antenna under test according to the measuring conditions described in clause 4;

b) replace the antenna under test with the standard antenna;

c) transmit the test signal from the source antenna at one of the test frequencies and move the standard antenna horizontally and vertically on the plane where the aperture plane of the antenna under test was located. Measure the received power at each point at a distance of two to four times the wavelength. The difference between the maximum and minimum measured values shall not exceed 1 dB. Then calculate the average value from the measured values and note it as P_{HA};

d) place the standard antenna apart from the antenna under test on a plane in which the aperture of the antenna under test is included. The distance between the centre of the antenna under test and that of the standard antenna shall be greater than 1,5 times the diameter of the antenna under test. Then measure the received power and note it as P_H;

e) calculate the difference $\Delta\alpha$ between P_H and P_{HA}

$$\Delta\alpha = P_H - P_{HA}\ ;$$

f) repeat b) to e) at other test frequencies;

g) if the antenna under test is designed to receive two orthogonal polarized waves, replace both the source antenna and the standard antenna with those of orthogonal polarization. Repeat a) to f) to calibrate the field intensity for orthogonal polarization, and note $\Delta\alpha$ for each polarization.

5.2 Antenna gain

5.2.1 Introduction

Antenna gain is defined as the ratio, generally expressed in decibels, of the received power of an antenna which is oriented to a given direction in a uniform field of given polarization to that of a polarization-matched isotropic lossless antenna in the same field.

Unless otherwise specified, the direction shall be given so as to obtain maximum received power.

For a multiple-beam antenna, the antenna gain is defined for each beam in the same way as mentioned above.

NOTE – The term "antenna gain" is identical to "partial gain" defined in IEV 712-02-44.

5.2.2 Method of measurement

The arrangement of the test equipment is shown in figure 3.

A circularly or linearly polarized standard antenna is used as the standard antenna corresponding to the polarization of the antenna under test. A polarization of a source antenna shall coincide with the polarization of the antenna under test.

NOTE – The direction of the field vector at the beam axis of the linearly polarized antenna is described as an angle measured from the θ direction of spherical coordinates fixed on the antenna. It is not normally necessary to indicate the measured or intended direction of the field vector, but if it is stated, present it in the results.

5.2.2.1 Single-beam antenna

The measurement for single-beam antennas shall be carried out using the following procedure:

a) set the source antenna and the antenna under test according to the measuring conditions described in clause 4;

b) locate the standard antenna at the same location as described in 5.1.2 d);

c) transmit a signal from the source antenna at one of the test frequencies, and set the received power at an appropriate level by adjusting the variable attenuator, and note the attenuation as L_0 (dB);

for a linearly polarized antenna, perform d) and e), for a circularly polarized antenna, skip d) and e);

d) adjust the polarization of the standard antenna to coincide with that of the antenna under test;

e) adjust the polarization of the source antenna to coincide with that of the standard antenna;

f) disconnect the receiver from the standard antenna and connect it to the antenna under test, and direct the beam axis to obtain the maximum received power, and set the received power at the same level as that obtained in c) by adjusting the variable attenuator, and note the attenuation as L (dB);

g) calculate the gain G by the following equation:

$$G = G_\mathrm{s} + L - L_0 + \Delta\alpha \quad \text{(dB)}$$

where G_s is the antenna gain of the standard antenna.

h) P_H should be monitored before and after the gain measurement, and its variation should not exceed 0,2 dB;

i) repeat b) to h) at other test frequencies;

j) if the antenna under test is designed to receive two orthogonal polarized waves, repeat b) to i) for the other polarization.

NOTE 1 – If there are reflections in the test range, alternative methods for antenna gain measurement may be applied (see annexes D and E).

NOTE 2 – The beam axis of the right-hand circularly polarized beam and that of the left-hand circularly polarized beam of an off-set paraboloidal reflector antenna are slightly deflected from the mechanical beam axis in opposite directions to each other.

5.2.2.2 Multiple-beam antennas

The same test procedure shall be adopted for each beam. If each output port of the beam can be terminated by a matched load, all output ports except for the measuring beam output port shall be terminated.

The direction of each beam axis shall be measured. The directions are expressed in spherical coordinates (θ_I , ϕ_I) i = 1, 2, ...n (n = number of beams) fixed on the antenna under test shown in figure 4.

The beam axis is calculated as the mean value of the angles at which the received power is 3 dB lower than the maximum received power in the beam.

5.2.3 Presentation of results

The results shall be listed in tables or presented graphically. Graphical examples are shown in figure 5.

The polarization in which the gain is measured shall be stated. For example, vertical polarization, right-hand circular polarization, and so on.

For a multiple-beam antenna, the beam whose gain is measured shall be stated. For example, beam 1, right-side beam, and so on.

5.3 Impedance matching

5.3.1 Introduction

This test measures the impedance matching of the antenna under test which should preferably be expressed in terms of the return loss ratio of the antenna, i.e. the amplitude of the reflection coefficient, in decibels; it may alternatively be expressed in terms of the standing wave ratio (SWR).

5.3.2 Method of measurement

The measurement shall be made by installing the antenna under test in an anechoic chamber or by directing its beam axis to the sky. To measure the return loss, a network analyzer should be used. The arrangement of the test equipment is shown in figure 6. If each output port of the beam can be terminated by matched load, all output ports except that for the measuring beam output port shall be terminated.

Measurement shall be carried out as follows:

a) calibrate the X axis of the X-Y recorder for the range of the frequency band by a sweep signal generator and the receiver;

b) terminate the output port of the directional coupler with a short-circuit terminator, and measure the output level of the coupling port by the receiver and set it as 0 dB. Then sweep the frequency from the lowest to the highest frequency as specified in 4.2, and calibrate the Y axis;

c) disconnect the output port from the terminator and connect it to one of the output ports of the antenna under test, and measure return loss;

d) repeat b) to c) for other output port(s).

NOTE 1 – The impedance matching measurement can be made with a directional coupler, a receiver and an X-Y recorder.

NOTE 2 – This method cannot be applied to the measurement of the receiving antenna including an SHF converter.

5.3.3 Presentation of results

The results shall be listed in a table or presented graphically. A graphical example is shown in figure 7.

When the impedance matching is required to be expressed in terms of *SWR*, *SWR* can be calculated by the following equation:

$$SWR = (1 + 10^{-L/20}) \,/\, (1 - 10^{-L/20})$$

The polarization in which the impedance is measured shall be stated. For example, vertical polarization, right-hand circular polarization, and so on.

For a multiple-beam antenna, the terminal whose impedance is measured shall be stated. For example, terminal for beam 1, terminal for right-side beam, and so on.

5.4 Radiation pattern

5.4.1 Introduction

The radiation pattern indicates the distribution of the ratio of the antenna gain as a function of the antenna direction to the maximum antenna gain on a given plane.

5.4.2 Method of measurement

The arrangement of the test equipment is shown in figure 8.

A circularly or linearly polarized source antenna is used corresponding to the polarization of the antenna under test.

NOTE – The direction of the field vector at the beam axis of the linearly polarized antenna is described as an angle measured from the θ direction of spherical coordinates fixed on the antenna. It is not normally necessary to indicate the measured or intended direction of the field vector, but if it is stated, present it in the results.

5.4.2.1 Single-beam antenna

The measurement shall be made using the following procedure:

a) set the centre of rotation of the antenna under test at its aperture centre. If it is difficult to set the centre of rotation at the aperture centre, the difference between both centres should be minimized;

b) transmit a signal at one of the test frequencies;

for a linearly polarized antenna, perform c) and d), for a circularly polarized antenna, skip c) and d);

c) adjust the polarization of the source antenna to coincide with that of the antenna under test;

d) set the beam axis of the antenna under test as 0° of the X-axis at the centre frequency;

e) set the received power at an appropriate level by adjusting the attenuator and note it as 0 dB. Then calibrate the Y axis of the X-Y recorder in the range of 0 dB to –50 dB;

f) set the pointers of the X axis and the Y axis at 0° (X axis) and 0 dB (Y axis), by readjusting the direction and the signal level;

g) rotate the antenna from –180° to +180° horizontally, and plot the curve of the received power relative to the rotating angle by the recorder;

h) expand the scale of the X axis of the recorder by a factor of approximately ten, and rotate the antenna from –18° to +18° and plot the curve again;

i) repeat a) to h) for another polarization. The antenna direction corresponding to 0° which is determined in f) shall not be changed;

j) repeat a) to i) at other test frequencies. The antenna direction corresponding to 0° which is determined in f) shall not be changed.

NOTE 1 – If there are reflections in the test range, an exact radiation pattern cannot be obtained. The pattern, however, can be measured with much improved accuracy by a method utilizing a network analyzer and a sweep signal generator (see annex E).

NOTE 2 – The pattern measurement plane should preferably coincide with the geostationary orbit plane. Instead of that patterns may be measured in four planes, each intersecting the axis of the main beam of the antenna. Two planes should be orthogonal and the other two planes should be at 45° to the first two. The measurement used should be clearly stated with the results.

NOTE 3 – The beam axis of the right-hand circularly polarized beam and that of the left-hand circularly polarized beam of an off-set paraboloidal reflector antenna are slightly deflected from the mechanical beam axis in opposite directions to each other.

5.4.2.2 Multiple-beam antennas

The same test procedure shall be adopted for each beam. If each output port of the beam can be terminated by a matched load, all output ports except for the measuring beam output port shall be terminated.

The pattern measurement plane should coincide with the geostationary orbit plane. If the antenna has two separated beams, the patterns may be measured in a plane which includes two beams.

The measurement angle near the beam axis shall be from –18° outside one beam to +18° outside another beam.

Radiation patterns in the same frequency shall be recorded without changing the Y-axis gain of the recorder.

NOTE 1 – If there are reflections in the test range, an exact radiation pattern cannot be obtained. The pattern, however, can be measured with much improved accuracy by a method utilizing a network analyzer and a sweep signal generator (see annex E).

NOTE 2 – The pattern measurement plane should preferably coincide with the geostationary orbit plane. Instead of that, patterns may be measured in four planes, each intersecting the axis of the main beam of the antenna. Two planes should be orthogonal and the other two planes should be at 45° to the first two. The measurement used should be clearly stated with the results.

NOTE 3 – The beam axis of the right-hand circularly polarized beam and that of the left-hand circularly polarized beam of an off-set paraboloidal reflector antenna are slightly deflected from the mechanical beam axis in opposite directions to each other.

5.4.3 Presentation of results

The results shall be presented graphically. An example is shown in figure 9.

For a multiple-beam antenna, each radiation pattern near the beam axis shall be recorded in one sheet.

5.5 Cross-polar radiation pattern

5.5.1 Introduction

The cross-polar radiation pattern indicates the distribution of the ratio of the antenna gain as a function of the antenna direction in the polarization orthogonal to that for which the antenna was designed, to the maximum antenna gain on a given plane.

5.5.2 Method of measurement

The arrangement of the test equipment is shown in figure 10.

A circularly or linearly polarized source antenna is used corresponding to the polarization of the antenna under test.

NOTE – The direction of the field vector at the beam axis of the linearly polarized antenna is described as an angle measured from the θ direction of spherical coordinates fixed on the antenna. It is not normally necessary to indicate the measured or intended direction of the field vector, but if it is stated, present it in the results.

5.5.2.1 Single-beam antenna

The measurement shall be made using the following procedure:

a) set the antenna under test and calibrate the X-Y recorder as described in 5.4.2.1 a) to f);

b) replace the source antenna with the cross-polar source antenna or rotate the source antenna 90° when the antenna under test is a linearly polarized antenna;

c) set the pointer of the X axis at 0° and rotate the antenna under test from –180° to +180° and plot the curve by the recorder;

d) repeat a) to c) for another polarization. The antenna direction corresponding to 0°, which is determined in c), shall not be changed;

e) repeat a) to d) at other test frequencies. The antenna direction corresponding to 0°, which is determined in c), shall not be changed.

NOTE 1 – If there are reflections in the test range, an exact cross-polar radiation pattern cannot be obtained. The pattern, however, can be measured with much improved accuracy by a method utilizing a network analyzer and a sweep signal generator (see annex E).

NOTE 2 – The pattern measurement plane should preferably coincide with the geostationary orbit plane. Instead of that patterns may be measured in four planes, each intersecting the axis of the main beam of the antenna. Two planes should be orthogonal and the other two planes should be at 45° to the first two. The measurement used should be clearly stated with the results.

5.5.2.2 Multiple-beam antennas

The same test procedure shall be adopted for each beam. If each output port of the beam can be terminated by a matched load, all output ports except for the measuring beam output port shall be terminated.

The pattern measurement plane should coincide with the geostationary orbit plane. If the antenna has two separate beams, the patterns may be measured in a plane which includes two beams.

NOTE 1 – If there are reflections in the test range, an exact cross-polar radiation pattern cannot be obtained. The pattern, however, can be measured with much improved accuracy by a method utilizing a network analyzer and a sweep signal generator (see annex E).

NOTE 2 – The pattern measurement plane should preferably coincide with the geostationary orbit plane. Instead of that patterns may be measured in four planes, each intersecting the axis of the main beam of the antenna. Two planes should be orthogonal and the other two planes should be at 45° to the first two. Which measurement is used should be clearly stated with the results.

5.5.3 Presentation of results

The results shall be presented graphically. An example is shown in figure 11.

5.6 Beam separation angle

5.6.1 Introduction

The beam separation angle is the angular distance between the axes of any two beams of a multiple-beam antenna.

5.6.2 Method of measurement

The beam separation angle Φ of (ϕ_i, θ_i) and (ϕ_j, θ_j) is calculated by the following equation:

$$\cos \Phi = \cos \theta_i \cos \theta_j + \sin \theta_i \sin \theta_j \cos(\phi_i - \phi_j)$$

5.6.3 Presentation of results

The results shall be presented in a table. Examples for a three-beam antenna are shown in tables 1 and 2.

Table 1 – Example of the list of beam axis directions

Beam	**V**		**H**		**R**		**L**	
	ϕ	θ	ϕ	θ	ϕ	θ	ϕ	θ
1								
2								
3								
Frequency:								

Table 2 – Example of the list of beam separation angles

Beam	**V**	**H**	**R**	**L**
1 – 2				
2 – 3				
3 – 1				
Frequency:				

5.7 Output terminal isolation

5.7.1 Introduction

The output terminal isolation of a single-beam antenna is defined as the ratio, generally expressed in decibels, of the received power of an antenna in a given direction and a given polarization, for which the antenna was designed, to the received power in the same direction and an orthogonal polarization.

The output terminal isolations of a multiple-beam antenna are the isolation described above, and the ratio of the received power of an antenna in a given direction and a given polarization, to the power received by another beam of the antenna in a co- and an orthogonal polarization.

The isolation contains cross-polarization discrimination, beam isolation and isolation of a polarization switcher.

5.7.2 Method of measurement

The arrangement of the test equipment is shown in figure 12.

A circularly or linearly polarized source antenna is used corresponding to the polarization of the antenna under test.

NOTE – The direction of the field vector at the beam axis of the linearly polarized antenna is described as an angle measured from the θ direction of spherical coordinates fixed on the antenna. It is not normally necessary to indicate the measured or intended direction of the field vector, but if it is stated, present it in the results.

5.7.2.1 Single-beam antenna

The measurement for single-beam antennas shall be made using the following procedure:

a) set the source antenna and the antenna under test according to the measuring conditions described in clause 4;

b) transmit a signal from the source antenna at one of the test frequencies;

c) direct the beam axis of the antenna under test to the source antenna;

d) adjust the polarization of the source antenna to coincide with the designed polarization of the antenna under test;

e) connect an attenuator and a receiver to the cross-polarization output port, and connect a matched load to the co-polarization output port;

f) set the received power at an appropriate level by adjusting the variable attenuator, and note the attenuation as L_0 (dB);

g) disconnect the attenuator and the receiver from the cross-polarization output port and connect them to the co-polarization output port, then connect the matched load to the cross-polarization output port;

h) set the received power at the same level as that obtained in f) by adjusting the variable attenuator, and note the attenuation as L (dB);

i) calculate the output terminal isolation I by the following equation:

$$I = L - L_0 \quad \text{(dB)}$$

j) repeat e) to i) at other test frequencies;

k) repeat a) to j) for the other polarization.

NOTE – The beam axis of the right-hand circularly polarized beam and that of the left-hand circularly polarized beam of an off-set paraboloidal reflector antenna are slightly deflected from the mechanical beam axis in opposite directions to each other.

5.7.2.2 Multiple-beam antenna

The measurement for multiple beam antennas shall be made using the following procedure:

a) set the source antenna and the antenna under test according to the measuring conditions described in clause 4;

b) transmit a signal from the source antenna at one of the test frequencies;

c) direct the beam axis of the antenna under test to the source antenna;

d) adjust the polarization of the source antenna to coincide with the designed polarization of the antenna under test;

e) connect an attenuator and a receiver to the cross-polarization output port, and connect matched loads to the co-polarization output port and output ports of other beams;

f) set the received power at an appropriate level by adjusting the variable attenuator, and note the attenuation as L_0 (dB);

g) disconnect the attenuator and the receiver from the cross-polarization output port and connect them to the co-polarization output port, and connect the matched load to the cross-polarization output port.

h) set the received power at the same level as that obtained in f) by adjusting the variable attenuator, and note the attenuation as L (dB);

i) calculate the output terminal isolation I by the following equation:

$$I = L - L_0 \quad \text{(dB)}$$

j) repeat e) to i) at other test frequencies;

k) repeat e) to i) for the output ports of the other beam;

l) repeat a) to k) for the other polarization;

m) repeat a) to l) for the other beams.

NOTE – The beam axis of the right-hand circularly polarized beam and that of the left-hand circularly polarized beam of an off-set paraboloidal reflector antenna are slightly deflected from the mechanical beam axis in opposite direction to each other.

5.7.3 Presentation of results

The results shall be presented in a table. Examples are shown in tables 3, 4, and 5.

Table 3 – Example of the list of output terminal isolations for a single-beam antenna

Antenna under test	Source antenna			
	V	H	R	L
V	---	dB	---	---
H	dB	---	---	---
R	---	---	---	dB
L	---	---	dB	---
Frequency:				

Table 4 – Example of the list of output terminal isolations for a linearly polarized multiple beam antenna (number of beams: 2)

Antenna under test	Source antenna			
	V_1	H_1	V_2	H_2
V_1	---	dB	dB	dB
H_1	dB	---	dB	dB
V_2	dB	dB	---	dB
H_2	dB	dB	dB	---
Frequency:				

Table 5 – Example of the list of output terminal isolations for a circularly polarized multiple beam antenna (number of beams: 2)

Antenna under test	Source antenna			
	R_1	L_1	R_2	L_2
R_1	---	dB	dB	dB
L_1	dB	---	dB	dB
R_2	dB	dB	---	dB
L_2	dB	dB	dB	---
Frequency:				

5.8 Figure of merit (G/T)

5.8.1 Introduction

G/T is defined as the ratio of the antenna gain to the antenna-SHF converter noise temperature referred to the antenna terminal.

G/T is measured as a parameter representing the total performance of the antenna under test with an SHF converter.

5.8.2 Methods of measurement

See IEC 61079-1.

If the antenna under test is designed to receive two orthogonal polarized waves, the measurement shall be made for each polarization.

For a multiple-beam antenna, the measurement shall be made for each beam.

The measurement should be normally carried out at elevation angles of 20°, 40° and 60°. These test elevation angles shall be chosen from the values given in the standard of the country for which the antenna under test is designed.

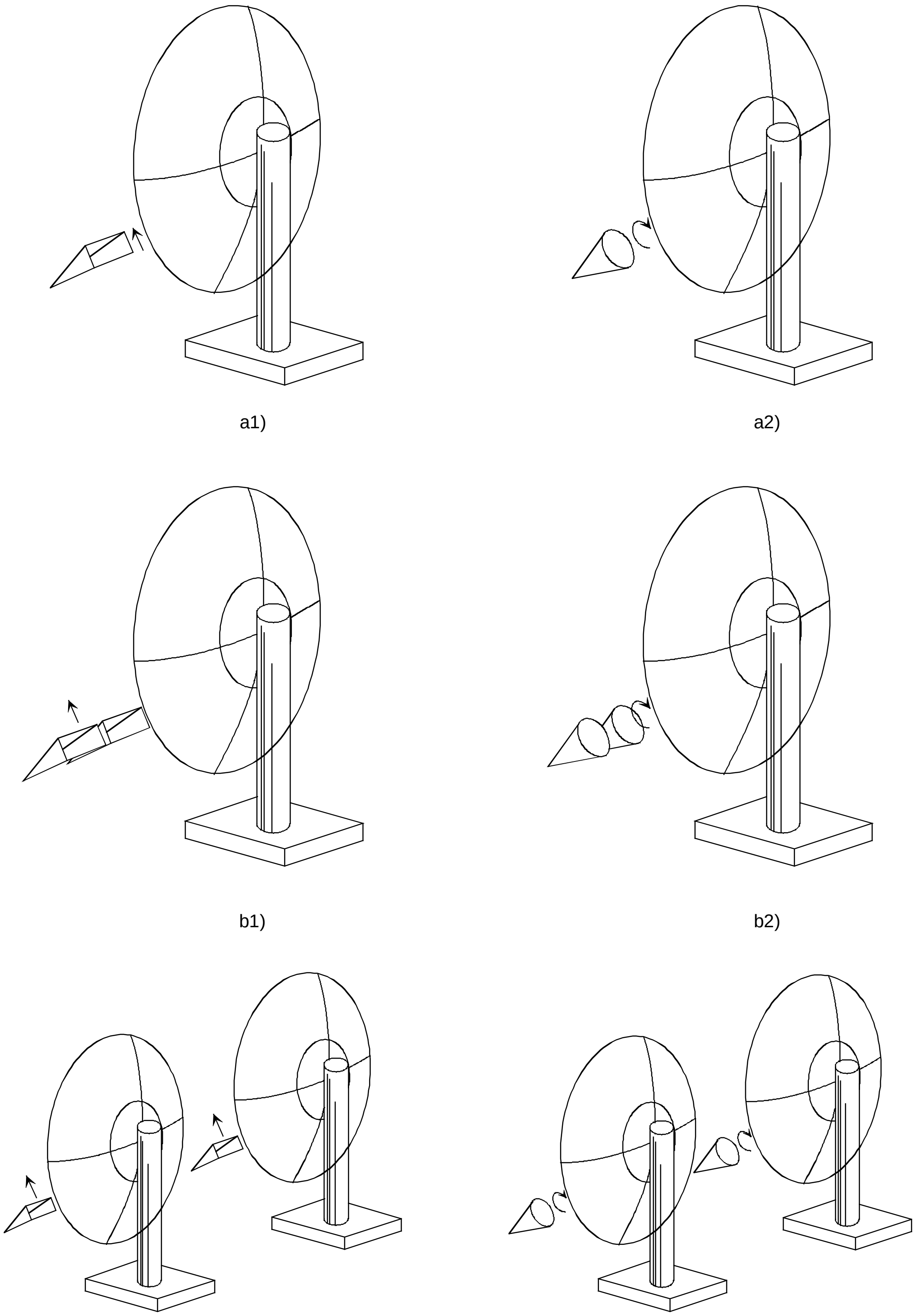
The ambient temperature shall be measured.

The type of test-site ground (soil, grass, concrete or metal) and its condition (dry or wet) shall be recorded.

5.8.3 Presentation of results

The results shall be listed in a table and presented graphically. A graphical example is shown in figure 13.

The elevation angle and the ambient temperature shall be indicated.



a1) a2)

b1) b2)

c1) c2)

Figure 1 – Typical configurations of six antenna types

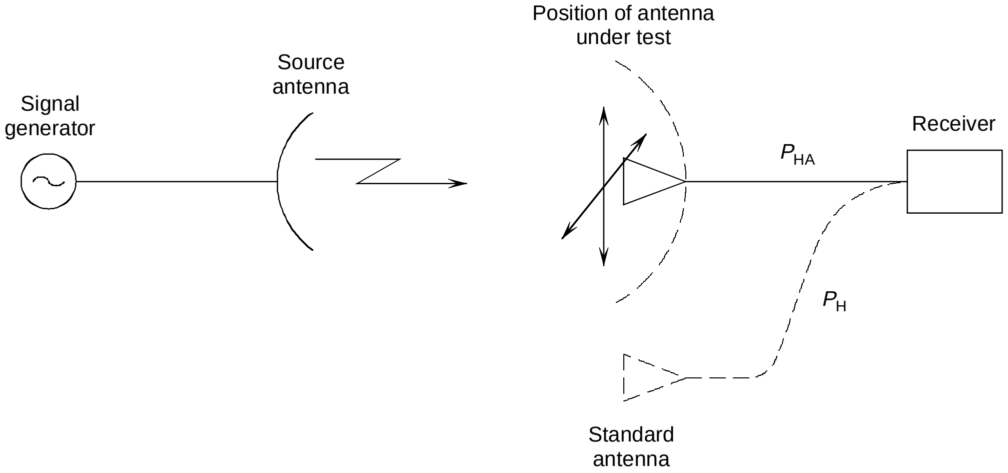


Figure 2 – Field intensity calibration

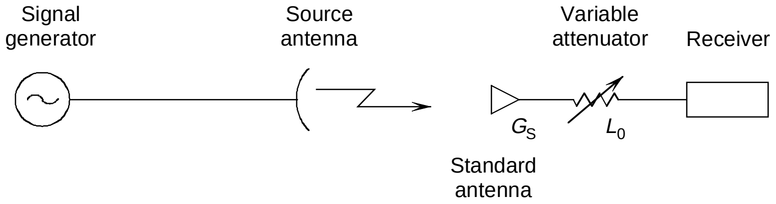


Figure 3a – Calibration

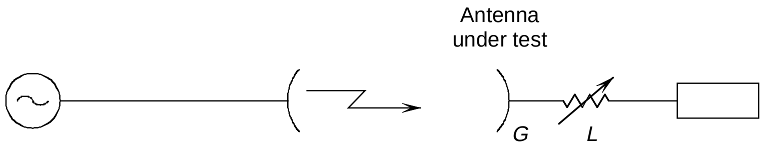


Figure 3b – Measurement

Figure 3 – Antenna gain measurement

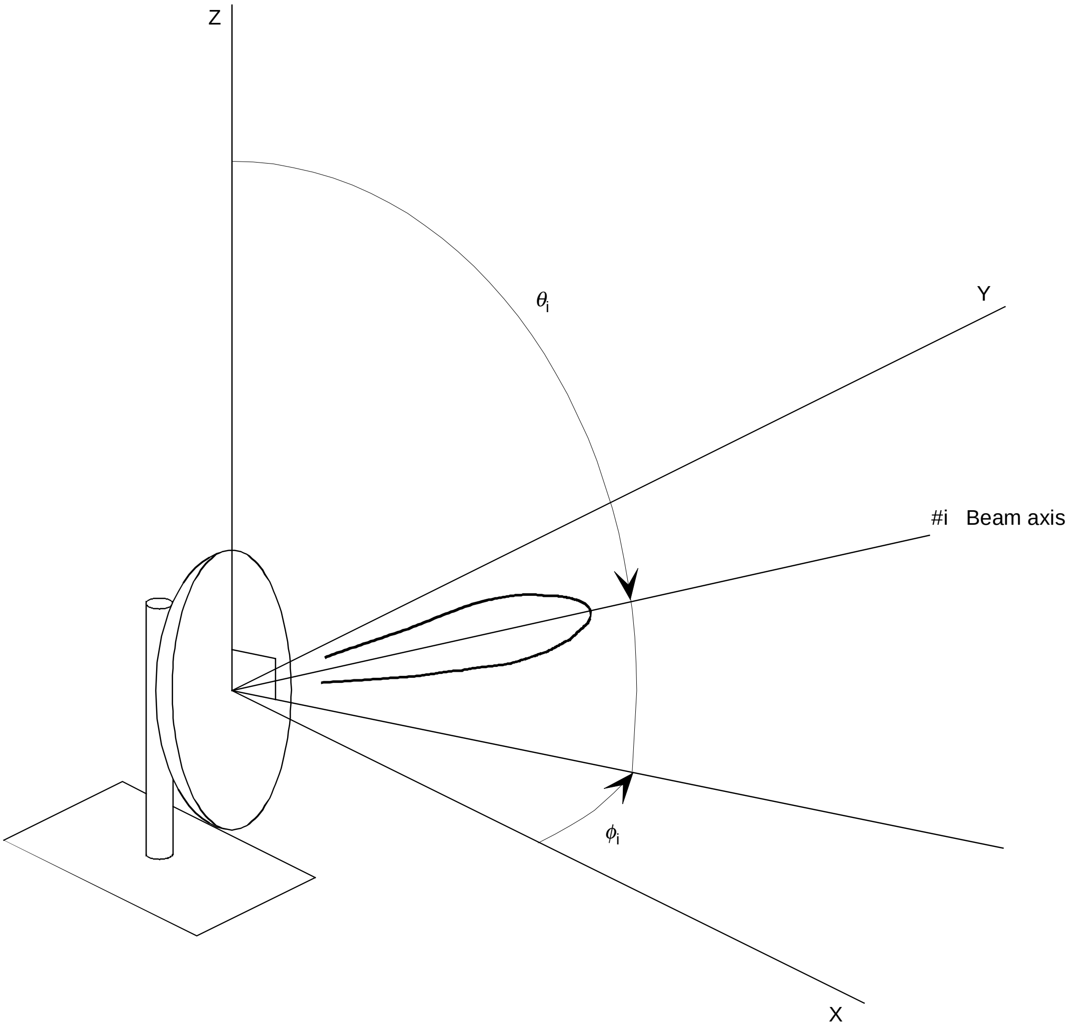


Figure 4 – Spherical coordinates

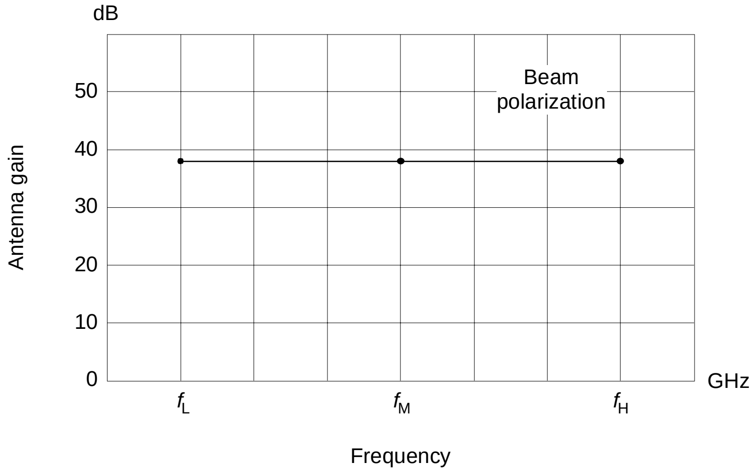


Figure 5 – Antenna gain graphical presentation

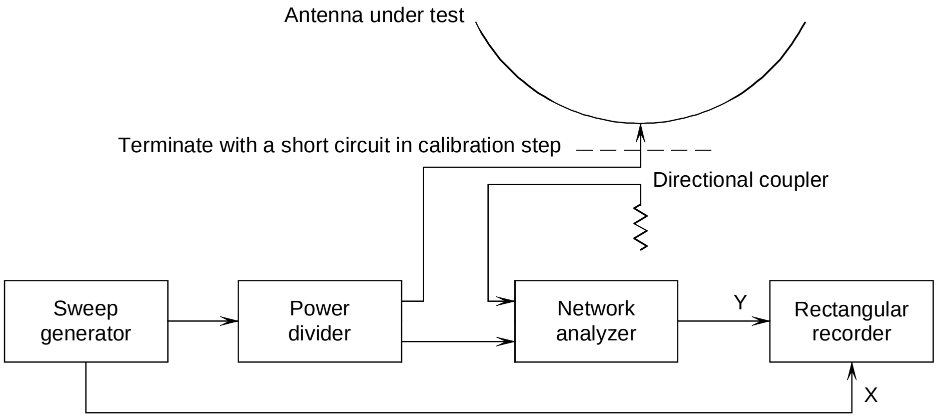


Figure 6 – Impedance matching measurement

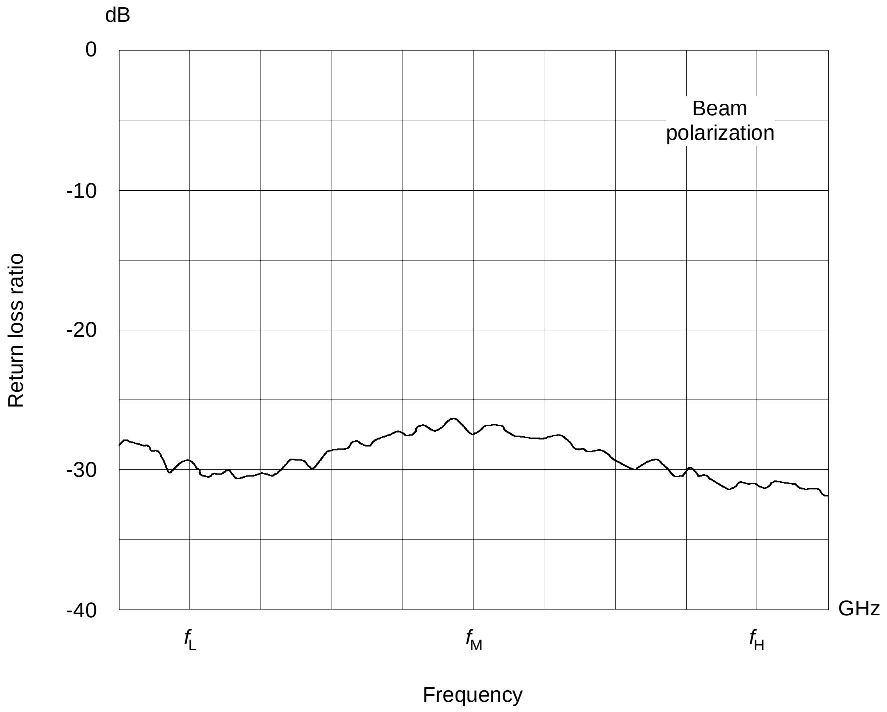


Figure 7 – Impedance matching graphical presentation

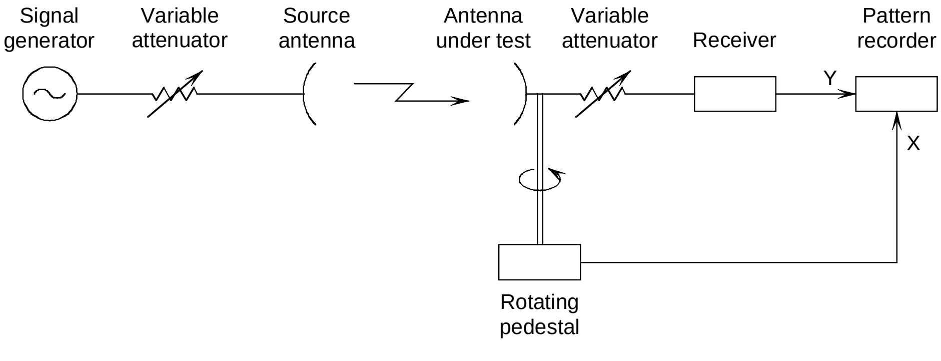


Figure 8 – Radiation pattern measurement

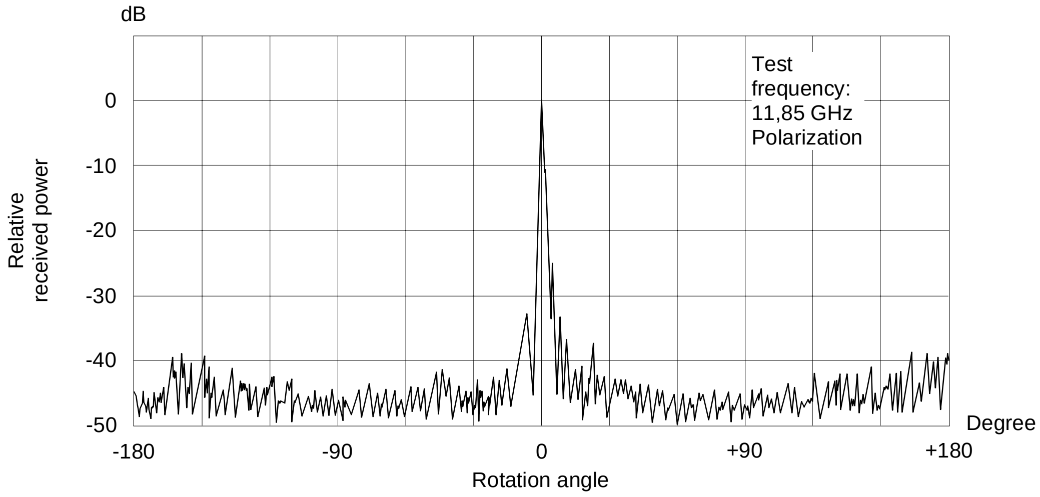


Figure 9a – Wide-angle radiation pattern

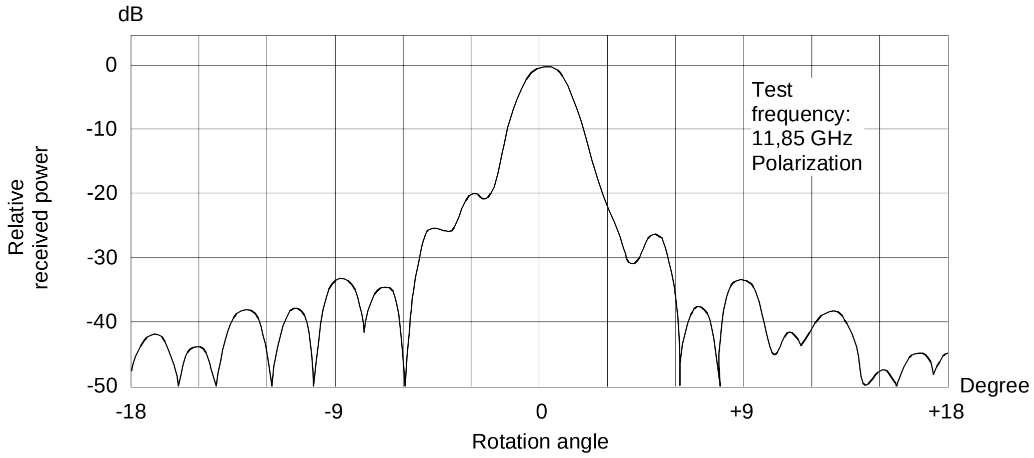


Figure 9b – Near-beam axis radiation pattern

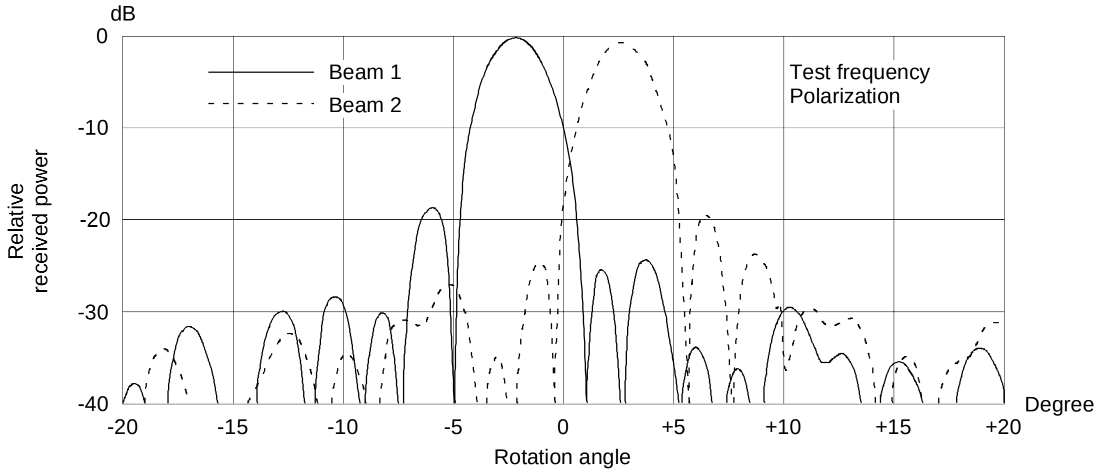


Figure 9c – Radiation pattern of multiple-beam antenna

Figure 9 – Radiation pattern graphical presentation

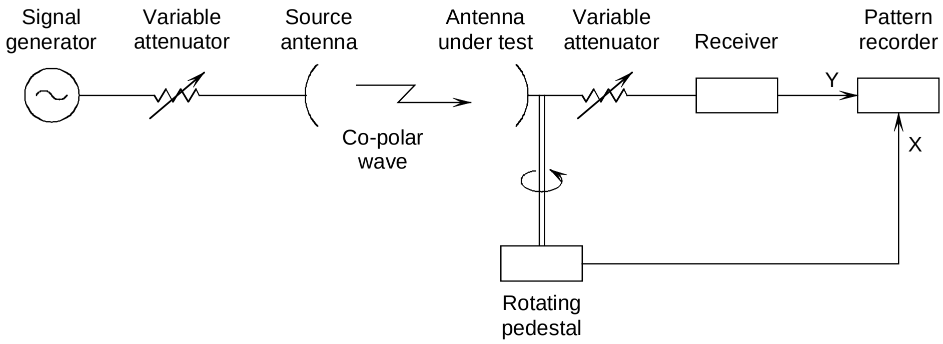


Figure 10a – Calibration

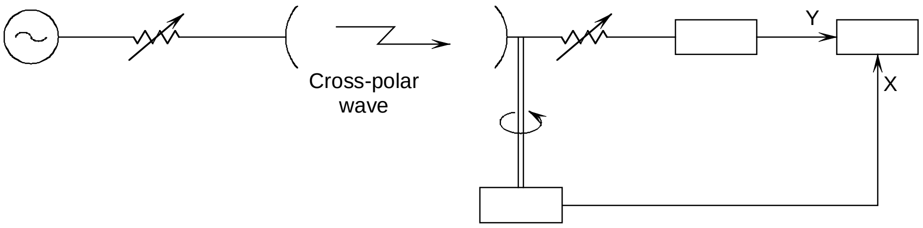


Figure 10b – Measurement

Figure 10 – Cross-polar radiation pattern measurement

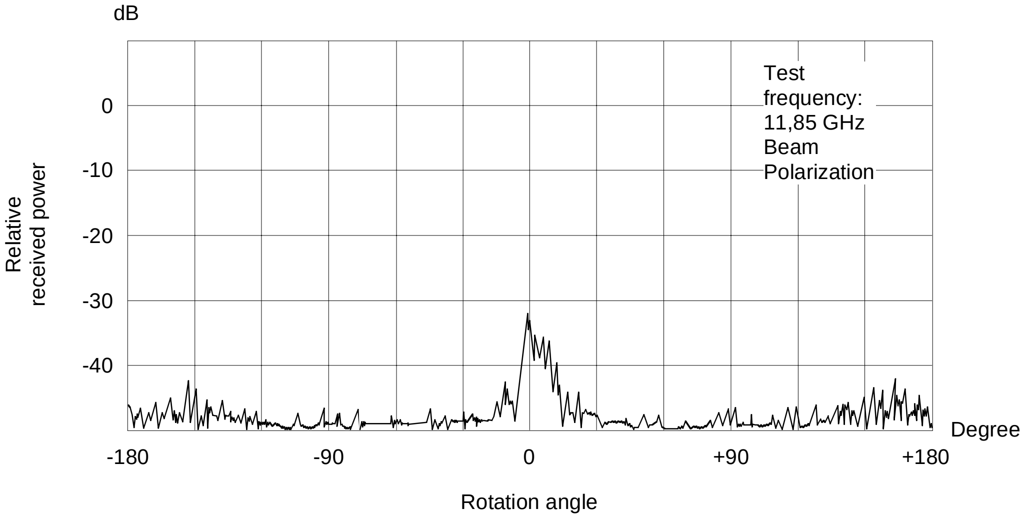


Figure 11 – Cross-polar radiation pattern graphical presentation

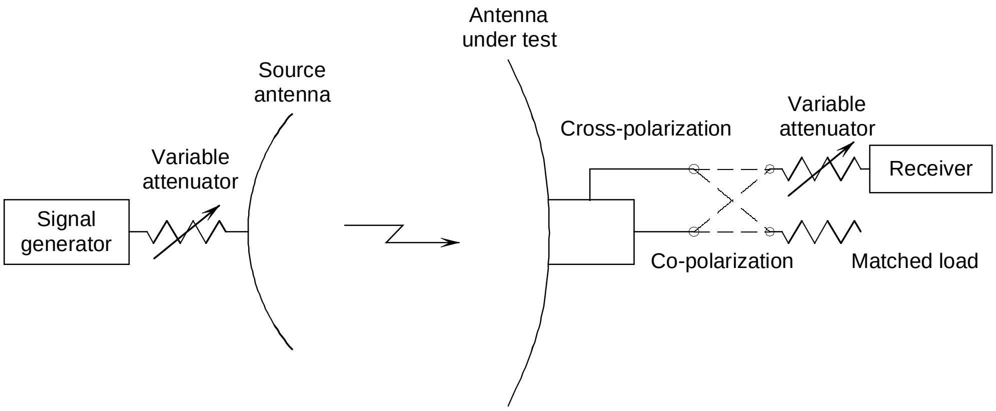


Figure 12a – Single-beam antenna

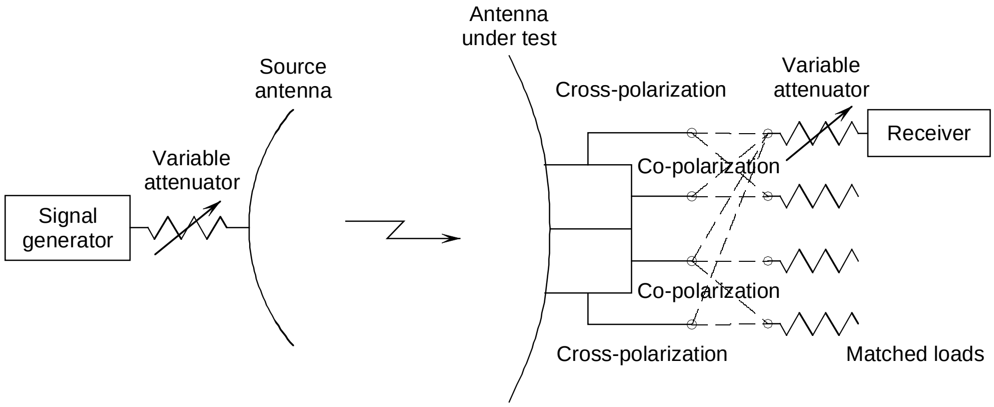


Figure 12b – Multiple-beam antenna

Figure 12 – Output terminal isolation measurement

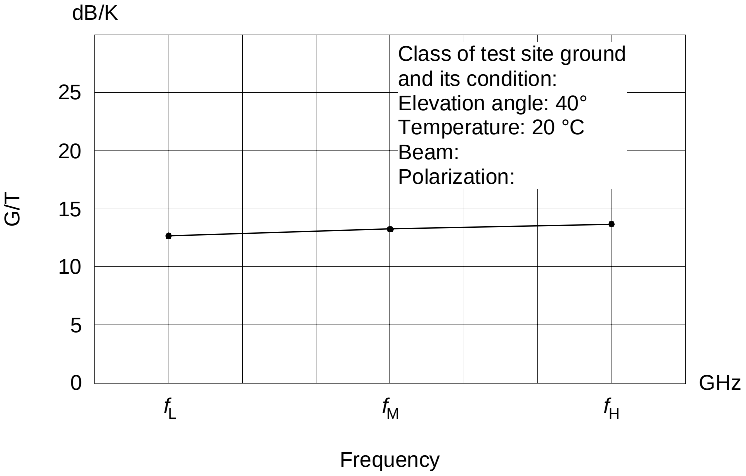


Figure 13 – G/T graphical presentation

Annex A
(informative)

Circularly polarized standard antenna

A.1 Purpose

To define the configuration and dimensions of a circularly polarized antenna as described in 4.5.1, and to describe the adjustment method for a circular polarizer. The standard antenna defined herein is one of the possible versions of a circularly polarized standard antenna.

A.2 Electrical characteristics

Frequency bandwidth	more than 500 MHz in 12 GHz band
Gain	23,0 dB ± 0,2 dB (at 12,2 GHz)
Axial ratio	less than 0,55 dB within the beam axis ±1°

A.3 Configuration and dimensions

The standard antenna consists of a conical horn, a polarizer and a circular-rectangular waveguide transformer, as shown in figure A.1. Figures A.2 and A.3 show the dimensions of the conical horn and the polarizer. The polarizer is made of a circular waveguide and two sets of four metal posts perpendicularly screwed into the waveguide along the waveguide axis. The sets of posts are arranged symmetrically at opposite sides of the waveguide.

A.4 Adjustment method

The post lengths d_1 and d_2 shall be adjusted until an axial ratio of 0,5 dB is obtained. The measurement method for the axial ratio is shown in figure A.4. The axial ratio can be measured by rotating the probe and recording the output level of the coaxial detector. The axial ratio of the polarizer shall be measured with a circular-rectangular waveguide transformer.

A.4.1 Procedure for post length adjustment

a) Vary the attenuation level of the attenuator and record the calibration curves by the X-Y recorder.

b) Set the initial lengths of d_1 and d_2 at 3,5 mm and 2,5 mm, respectively, and measure the axial ratio.

c) Vary d_1 and d_2 maintaining the ratio of d_1 to d_2 within 1,3 to 1,5, so that the axial ratio becomes minimum in the specified frequency range.

d) Ensure that the SWR of the polarizer remains less than 1,1.

A.4.2 Devices for measurement

A.4.2.1 Circular-rectangular waveguide transformer

Either a step transformer or a tapered transformer is applicable. The SWR at the circular waveguide port shall be less than 1,05. A resistive film should be inserted in the transformer in order to terminate a wave whose polarization is orthogonal to that of the input linearly polarized wave. An orthomode transducer may be used instead of the circular-rectangular waveguide transformer.

A.4.2.2 Rotating probe

This consists of a circular waveguide with two rotatable circular flanges (type designation to be provided in an IEC publication) and an SMA connector (IEC 60169-15) with an inner conductor of about 0,25 mm which is inserted into the waveguide. The insertion depth should be about 1 mm or less. A shorter depth is preferable, provided that the signal can be detected.

A.4.2.3 Termination

The termination is made up of a conical resistive material inserted into the circular waveguide. The SWR shall be less than 1,05.

A.5 Example of measured results

Measured results of a polarizer are shown in figures A.5 and A.6. SWR was less than 1,1 at a frequency range of 10,7 GHz to 12,5 GHz. The estimated degradation of the antenna gain and the axial ratio, caused by the reflection from each component and the mechanical tolerances, were within 0,2 dB and 0,05 dB, respectively.

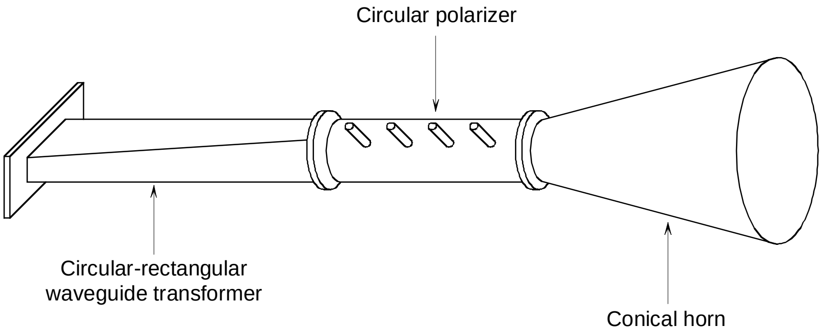
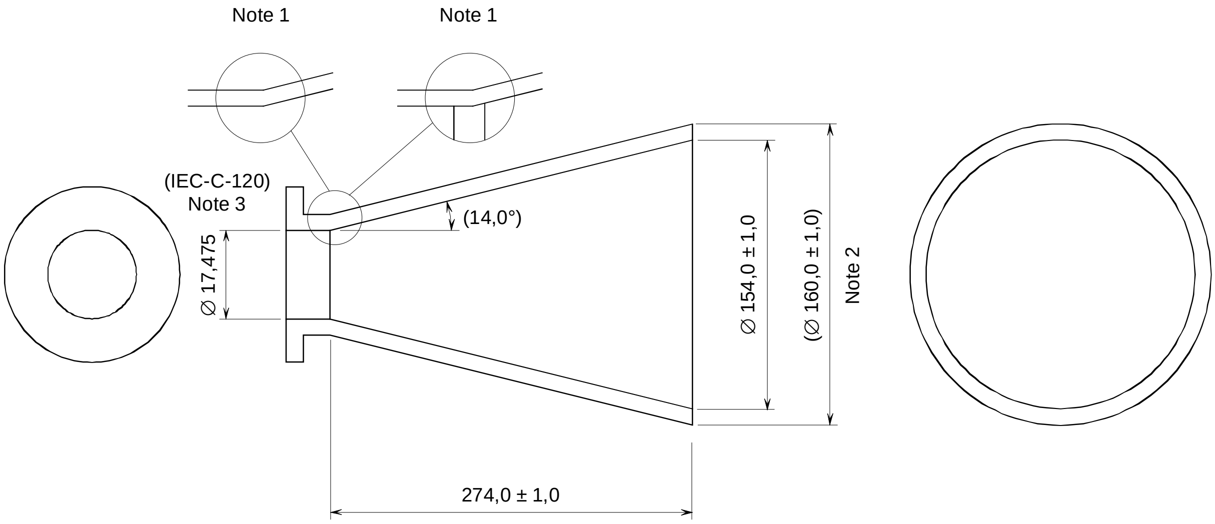


Figure A.1 – Circularly polarized standard antenna



Dimensions in millimetres

NOTE 1 – A rounded shape or double flare is preferable.

NOTE 2 – Recommended value.

NOTE 3 – See IEC 60153-4, table 1a[1].

Figure A.2 – Dimensions of a conical horn

---

[1] See bibliography.

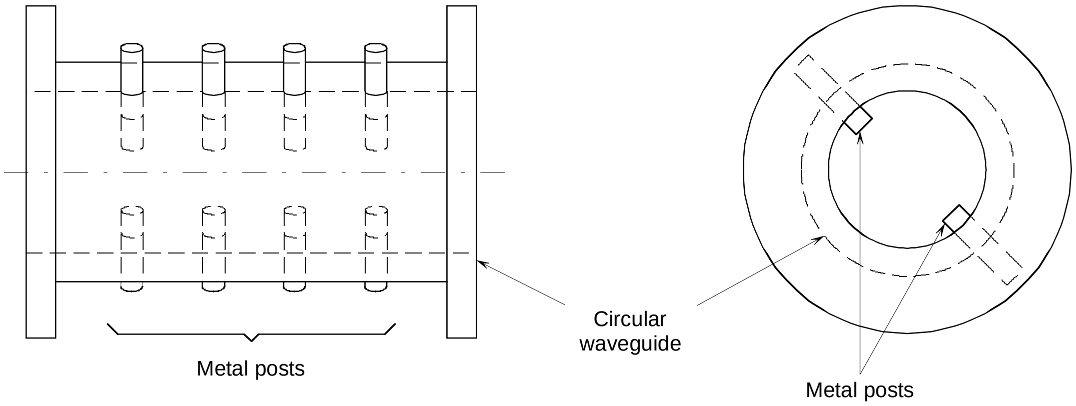
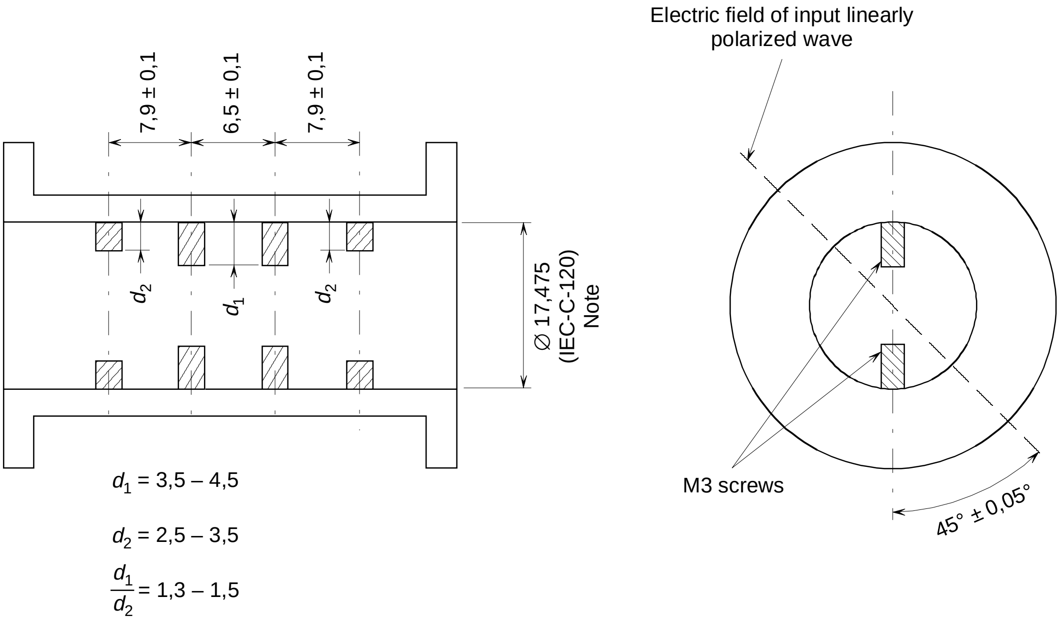


Figure A.3a – Structure



Dimensions in millimetres

NOTE – See IEC 60153-4, table 1a[1].

Figure A.3b – Dimensions

Figure A.3 – Circular polarizer

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[1] See bibliography.

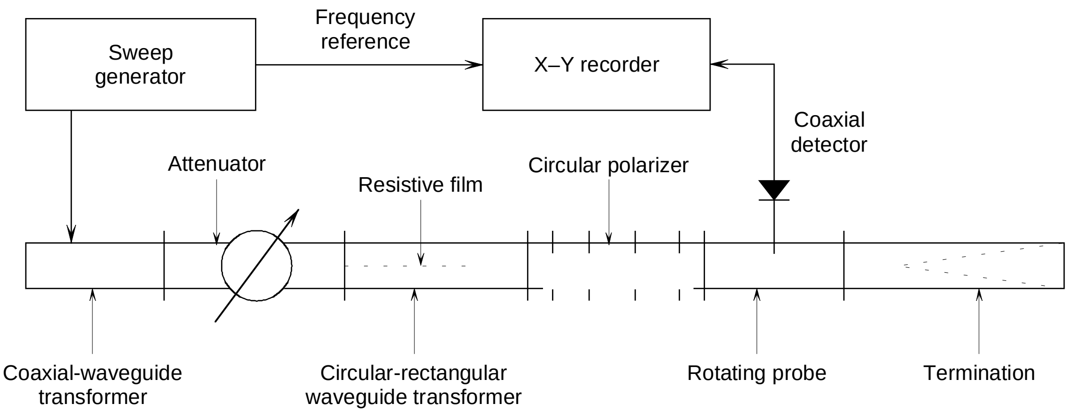


Figure A.4 – Measurement method for axial ratio

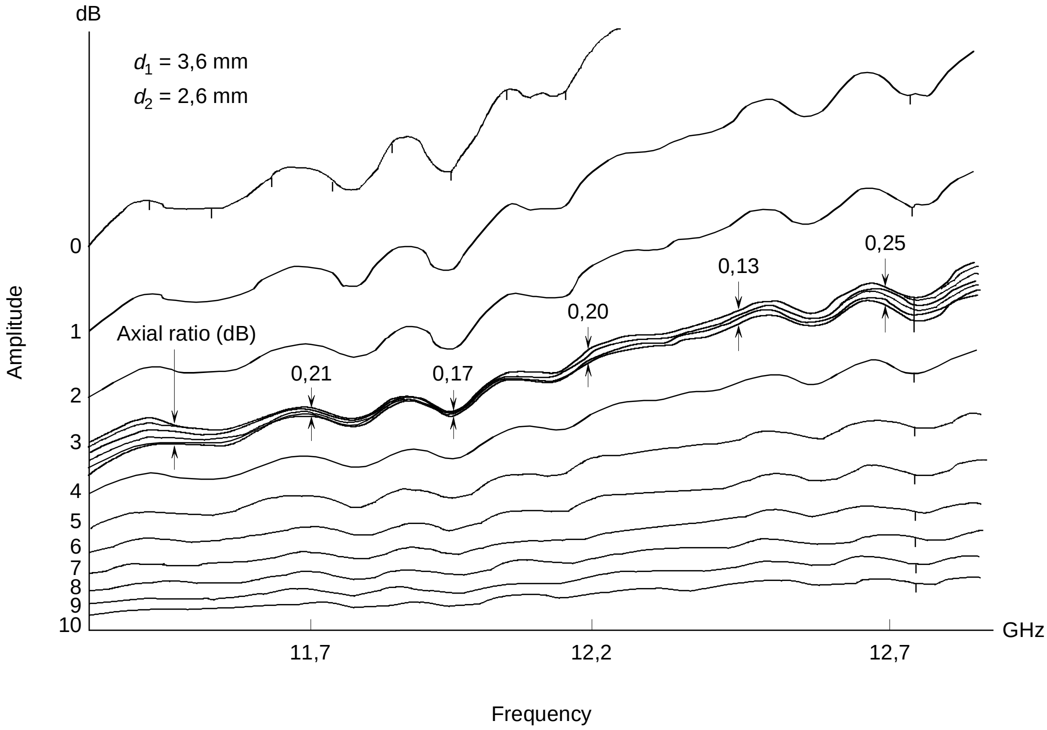


Figure A.5 – Example of measured axial ratio of a polarizer

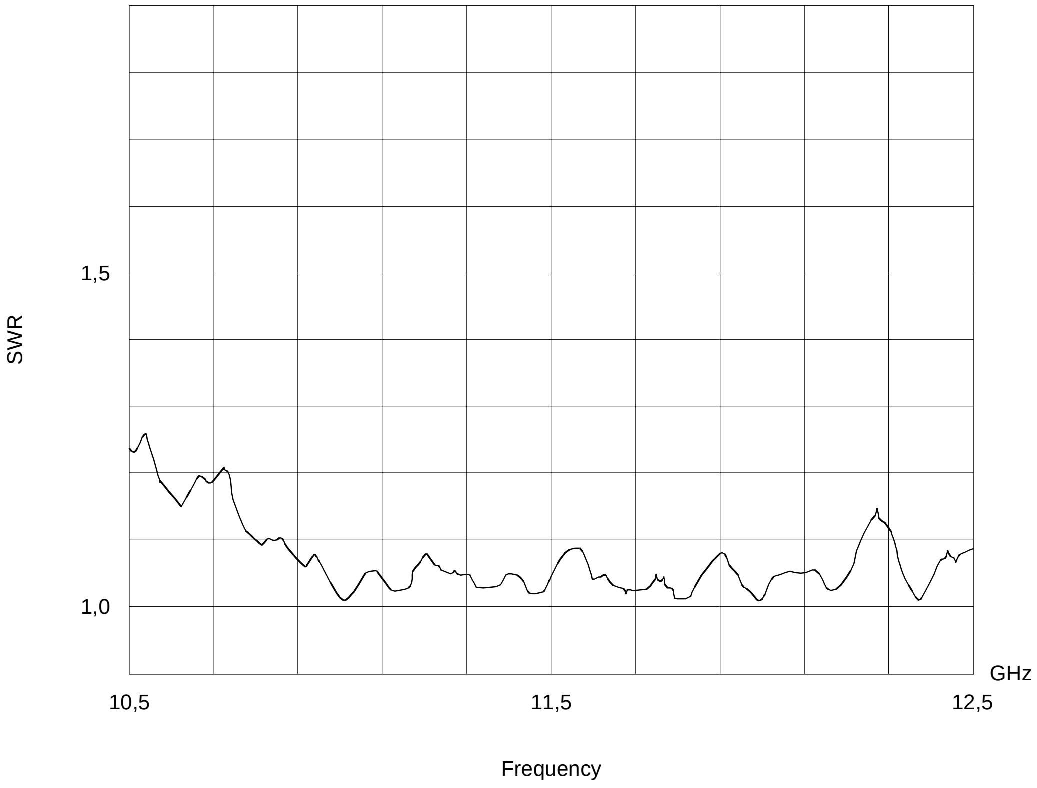


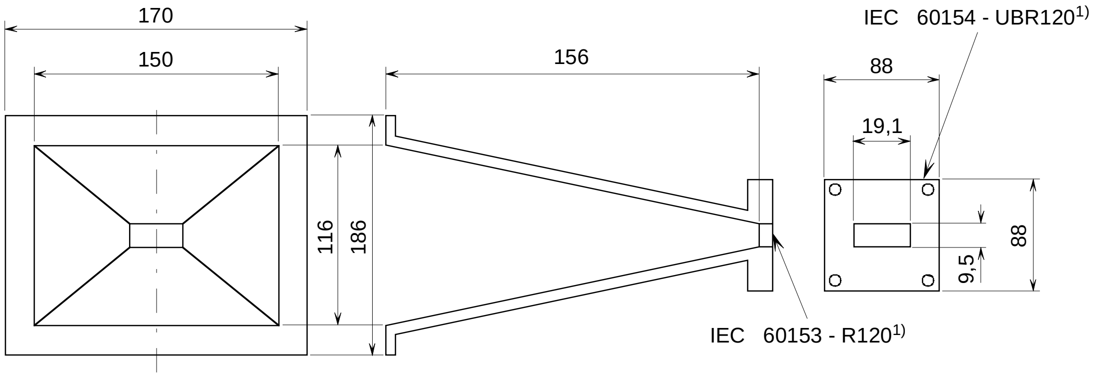
Figure A.6 – Example of measured SWR of a polarizer

Annex B
(informative)

Linearly polarized standard antenna

An example of the linearly polarized standard antenna in 4.5.2 is shown in figure B.1.

The gain of the antenna is 20 dB ± 0,1 dB (11 GHz to 13 GHz).



Dimensions in millimetres

Figure B.1 – Linearly polarized standard antenna

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[1] See bibliography.

Annex C
(normative)

Method for confirmation of the cross-polarization discrimination of a source antenna

C.1 Purpose

To define a method which can confirm that the cross-polarization discrimination of the circularly polarized source antenna is lower than a specified value.

C.2 Method of measurement

a) Set the standard antenna and the co-polarized source antenna as shown in figure C.1. The two beam axes shall be coincident.

b) Measure the received power P_c.

c) Replace the source antenna with the cross-polarized source antenna.

d) Measure the received power P_0.

e) Rotate one of the antennas 90° around the beam axis.

f) Measure the received power P_{90}.

g) Calculate P_{av} as:

$$P_{av} = (P_0 + P_{90}) / 2P_c$$

h) Verify that P_{av} is lower than the specified value.

P_{av} is always higher than the cross-polarization discrimination of the cross-polarized source antenna, and therefore, when P_{av} is lower than the specified value, the cross-polarization discrimination of the source antenna is assured to be less than the specified value, even if the cross-polarization discrimination of the standard antenna is not infinite.

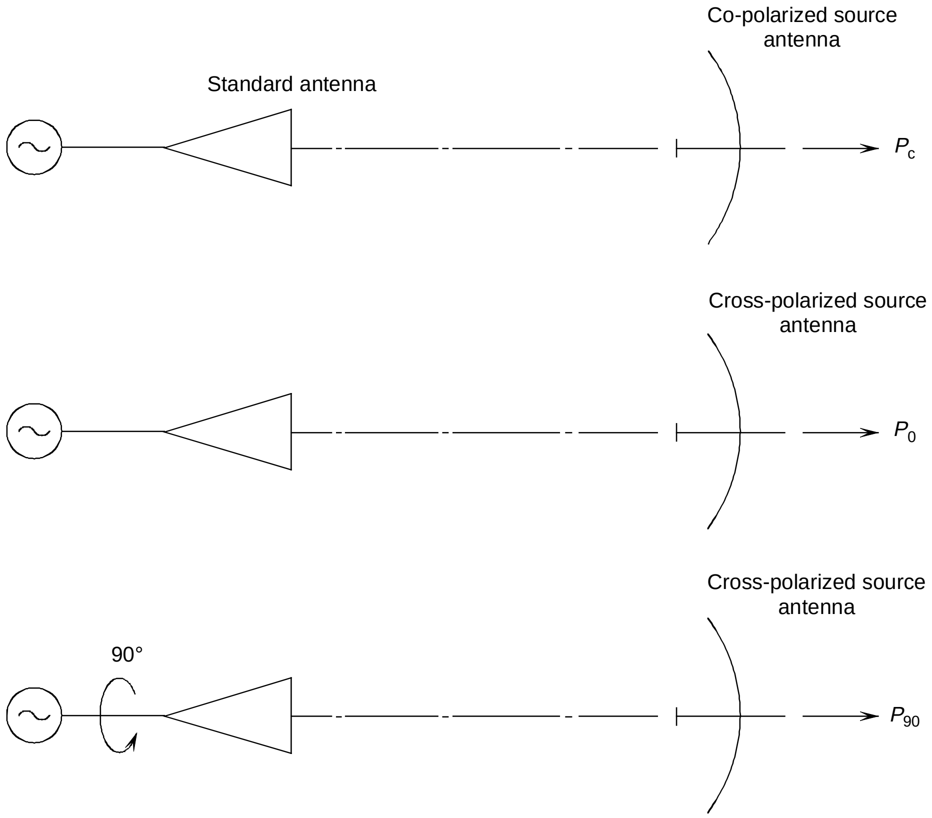

Co-polarized source antenna
Standard antenna
P_c
Cross-polarized source antenna
P_0
Cross-polarized source antenna
90°
P_{90}

Figure C.1 – Cross-polarization discrimination confirmation

Annex D
(informative)

Method of measurement of antenna gain utilizing DBS/FSS signals

D.1 Purpose

To define an alternative method for measuring the antenna gain utilizing direct broadcast by satellite (DBS)/fixed satellite service (FSS) signals (see 5.2.2.1).

D.2 Introduction

The normal method for measuring the gain of an antenna requires a large test site that is substantially reflection-free. These stringent requirements can be avoided by using a satellite broadcast signal as the signal source. However, the modulation will disturb the measurement unless it is cancelled.

The method described uses a second receiver in addition to the unit under test. The second receiver provides a local oscillator signal for mixing with the i.f. output of the test unit. Since both signals carry the same modulation, it will be cancelled out, and the resulting output is a line spectrum suitable for measurement purposes. The second receiver is also used to provide a reference signal. As both receivers look at the same satellite, any level fluctuation of the incoming signal will affect each unit similarly, and such level changes can be compensated (see bibliography).

D.3 Method of measurement

A circularly polarized satellite broadcast signal can be utilized as a test signal if the signal is converted to an unmodulated signal spectral line and the carrier-to-noise ratio is improved.

The method described here makes it possible to realize these conditions. The arrangement of the test equipment for measuring the antenna gain is shown in figure D.1. The measurements shall be made under the following conditions and procedure.

D.3.1 Measuring conditions

a) Testing site: a location where signals from satellites are not reflected into the receiving antennas.

b) Test frequency: broadcast frequencies.

D.3.2 Measuring procedure

a) The standard antenna and the reference outdoor unit are set on their own supporting apparatus which is capable of adjusting the azimuth and elevation angles.

   A satellite broadcast signal is received after arranging the measurement equipment as in figure D.1. The local oscillator LO2 is adjusted in accordance with the broadcast channel to be measured in order to produce a fixed i.f. The attenuators ATT 1 and ATT 2 should be set to 0 dB and 40 dB (or more), respectively. Each antenna direction is adjusted to maximize the received power, observing the spectrum analyzer connected at port 1 or port 2.

NOTE – In this measuring system, the output of the SHF converter or the first i.f. is converted again to the second i.f. which can be arbitrarily chosen. It is convenient to choose the same second i.f. as the indoor unit, since the frequency converter and band-pass filter (BPF) can be procured easily.

b) The spectrum analyzer is connected at port 3 and the line spectrum is observed at a frequency of $f_3 + \Delta f_1 + \Delta f_2$. If the power level difference between the main spectrum and sidebands is smaller than 20 dB, an adjustable delay line should be inserted before the combiner. The sideband levels can be reduced by adjusting the electrical length.

c) The direction of the standard antenna is readjusted so as to maximize the received power.

d) The attenuation of ATT 2 is decreased to observe the line spectrum at f_3 at port 3 which is created by introducing only the reference outdoor unit output signal. It is then adjusted so that the power level becomes the same level as the spectrum observed in procedure c). This power level is called the reference level. Also in this case, an adjustable delay line should be inserted before ATT 2 if the sideband levels exceed the level given in b).

e) The antenna under test is installed instead of the standard antenna, and the direction is adjusted to maximize the received signal level.

f) ATT 1 is adjusted so that the line spectrum caused by the antenna under test becomes the same level as the reference level. The gain of the antenna under test is calculated as follows:

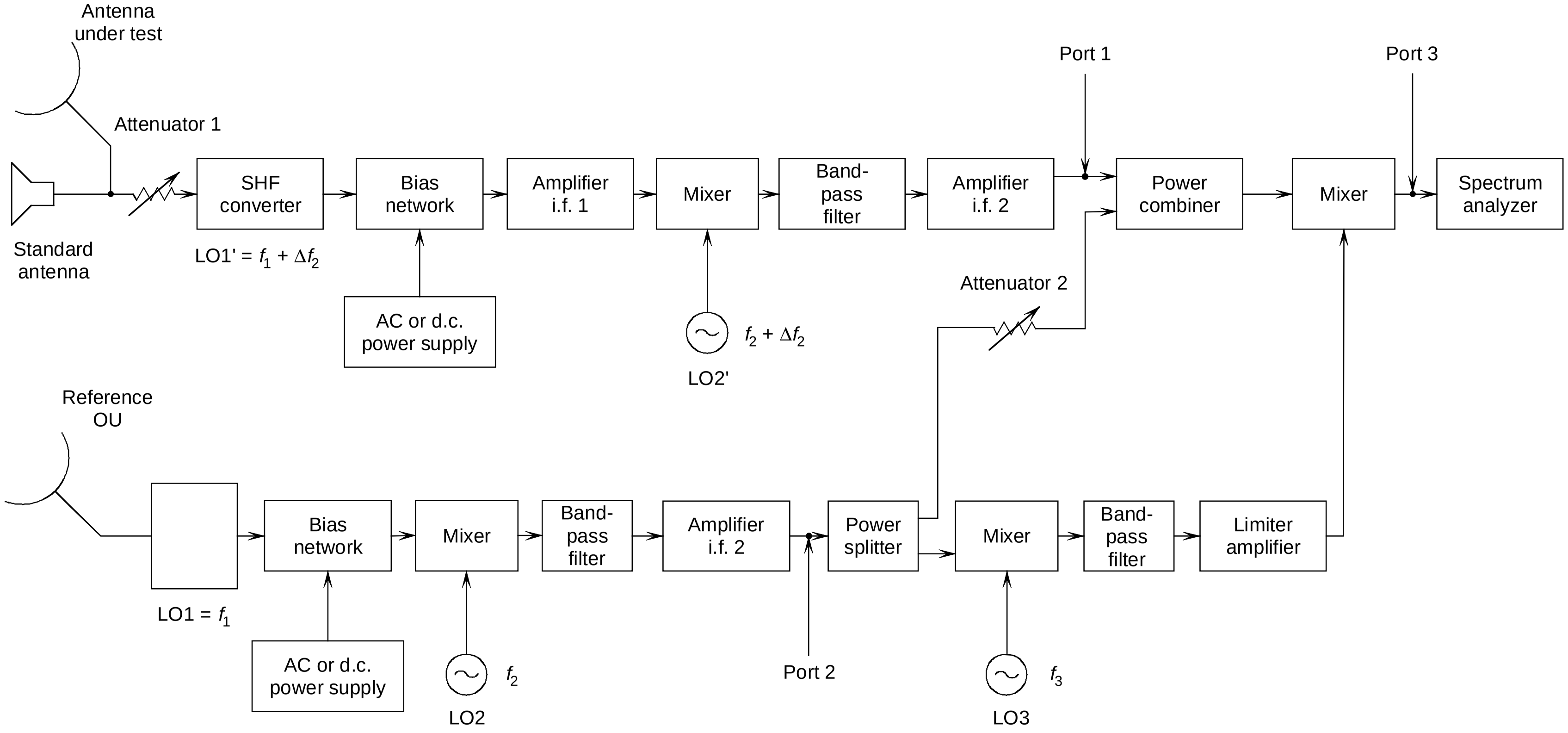
$$G_a = G_s + L_1 \quad \text{(dB)}$$

where

G_a is the gain of the antenna under test (dB);

G_s is the gain of the standard antenna (dB);

L_1 is the attenuation of ATT 1 (dB).



Key

LO = local oscillator

Figure D.1 – Antenna gain measurement utilizing DBS/FSS signals

Annex E
(informative)

Method of measurement of an antenna utilizing a network analyzer

E.1 Purpose

To define a method for verifying the antenna gain and radiation pattern measurement methods by means of a network analyzer with a time-domain gating feature (for further references see bibliography).

E.2 Block diagram of measurement system

The measurement system block diagram is shown in figure E.1.

E.3 Theory of measurement

The frequency-domain and the time-domain responses of a network are related by the inverse Fourier transform. Therefore, it is possible to characterize the response of an antenna in the frequency domain (magnitude and phase) and mathematically generate the time-domain response. A network analyzer which has the capability of calculating the antenna time domain response from the frequency-domain data gives the responses of the antenna to a pulsed RF signal.

If there are some ground-path reflections, the time-domain response can identify the direct-path response and the reflected path responses that arrive later in time. Once the unwanted path responses have been identified, the time-domain gating is used to remove their effects from the measured data in both time and frequency domains, as shown in figure E.2. Thus, only the main-path response in the frequency domain can be obtained by the Fourier transform.

E.4 Verification of the measurement system

Verification of the measurement system is performed by height pattern measurement. Figure E.3 shows an example of a height pattern measurement apparatus. The variation in the height pattern should be minimized by varying the following two parameters:

a) Frequency window

Minimum sweep frequency range (GHz) = 3,0/λ (m)

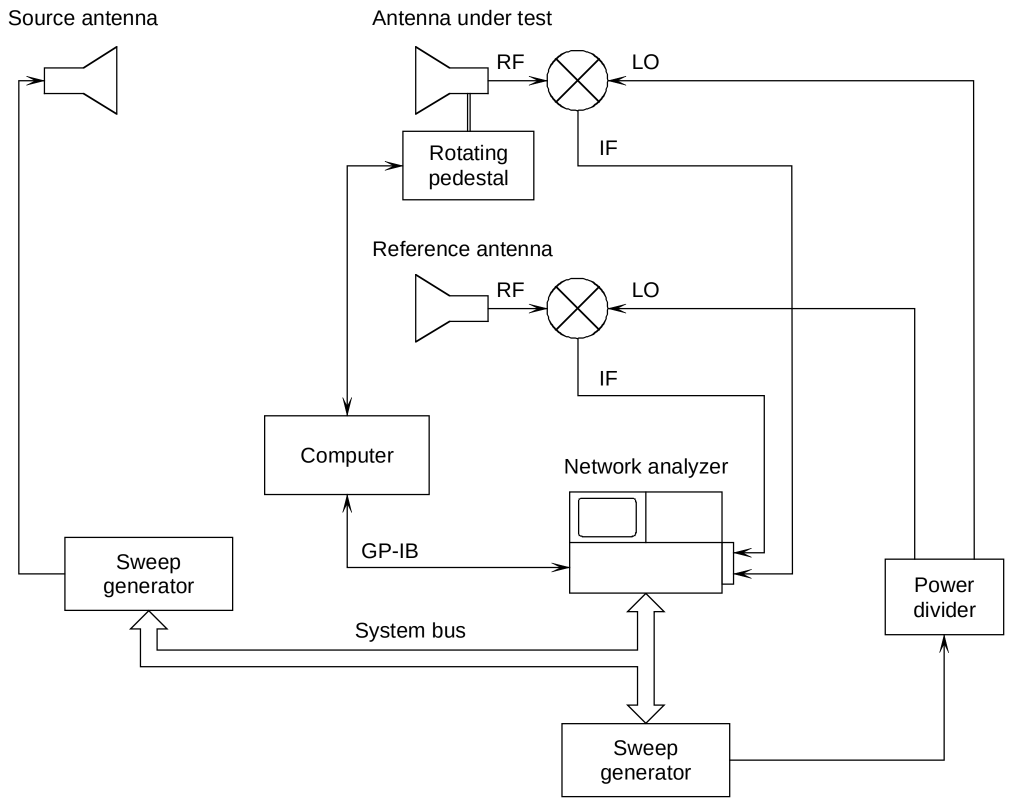
where λ is the path difference between a direct and a reflected wave.

b) Time gate window

Figure E.4 shows the impulse response of the network analyzer and the recommended time gate. The time gate should be chosen so that the signal level of the impulse response will be between –20 dB and –40 dB.

If the selected parameters cannot make the height pattern less than ±0,5 dB, the reflected waves from the surroundings should be suppressed by covering the surroundings with absorbers.

After the above procedure, the pattern for an antenna whose pattern is already known should be measured to verify the selected parameters.



Key

RF	= radiofrequency
LO	= local oscillator
IF	= intermediary frequency
GP-IB	= General Purpose Interface Bus

Figure E.1 – Measurement system block diagram

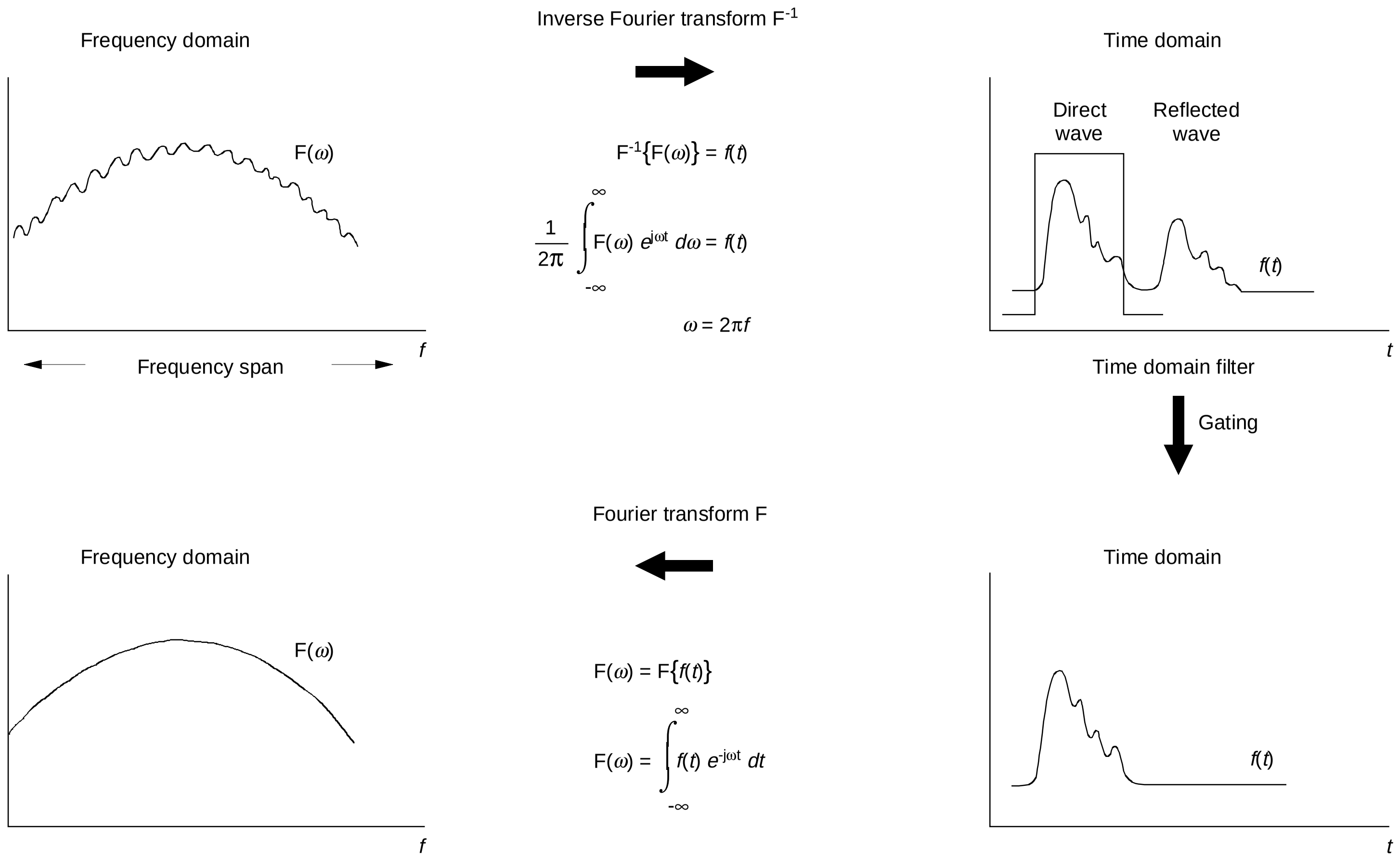


Figure E.2 – Elimination of reflective waves

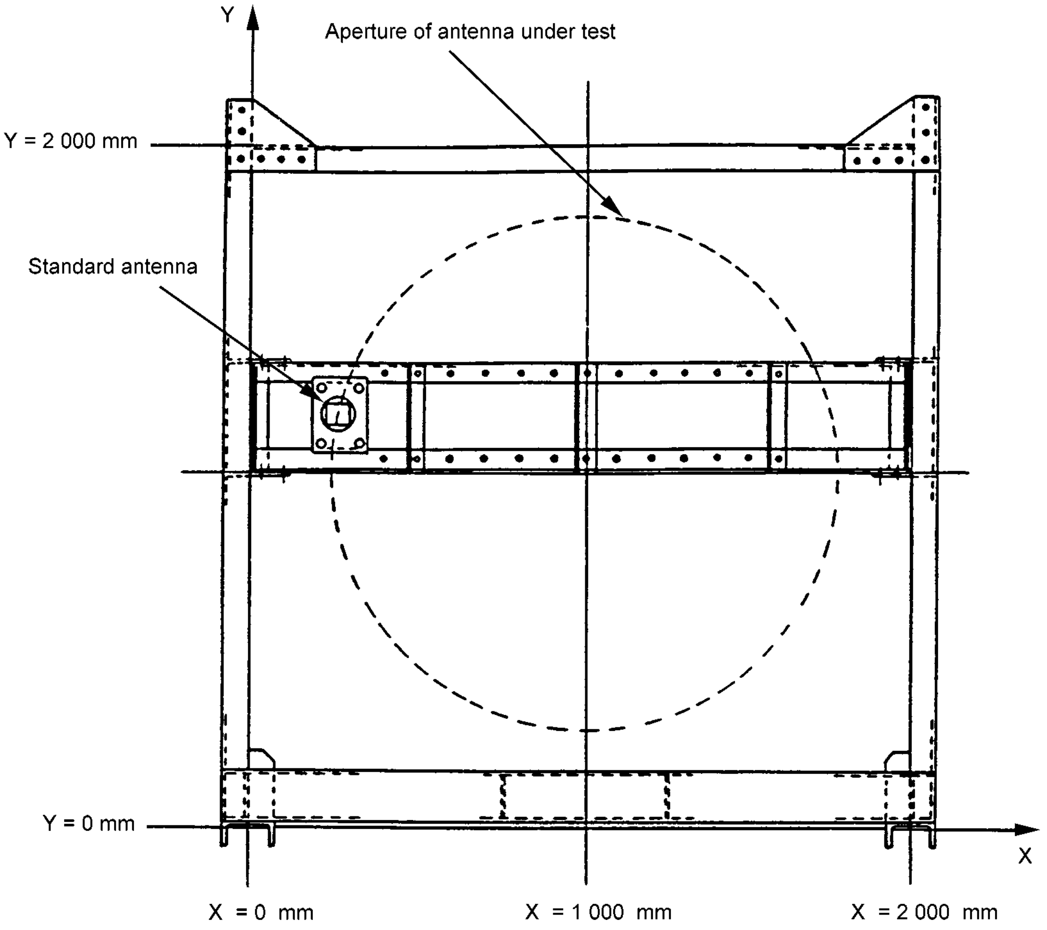


Figure E.3 – Height pattern measurement apparatus

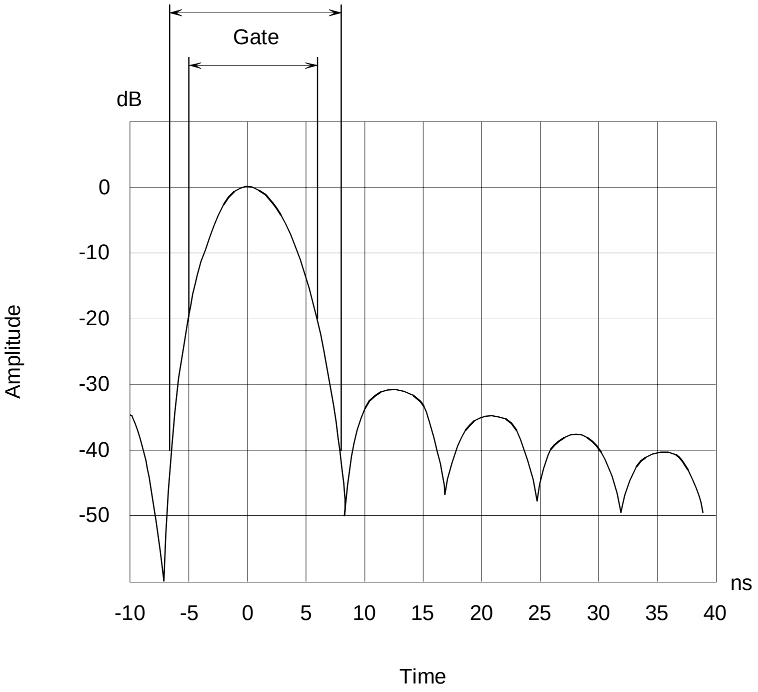


Figure E.4 – Time gate window

Bibliography

The following publications contain relevant information concerning this standard.

IEC 60153 (all parts), *Hollow metallic waveguides*

IEC 60154 (all parts), *Flanges for waveguides*

IEC 60169–15:1979, *Radio-frequency connectors – Part 15: R.F. coaxial connectors with inner diameter of outer conductor 4,13 mm (0,163 in) with screw coupling – Characteristic impedance 50 ohms (Type SMA)*

IEC 61319-1:1995, *Interconnections of satellite receiving equipment – Part 1: Europe*

IEC 61319-2:1997, *Interconnections of satellite receiving equipment – Part 2: Japan*

H. Isono and K. Ohmaru: *A new method for measuring satellite broadcast field intensity and a measurement method for antenna gain and G/T using a satellite broadcast signal,* NHK Laboratories Note, No. 361, pp.1-9 (1988)

J.W. Boyles: *Long range antenna measurements with the HP 8510 using harmonic mixers,* Antenna measurement techniques association 8th annual meeting and symposium, Sept 23-25, 1986, Ottawa

WARC BS-77: *World Administrative Radio Conference for the Planning of the Broadcasting-Satellite Service* (Geneva, 1977)

RARC SAT-83: *Regional Administrative Radio Conference for the Planning in Region 2 of the Broadcasting-Satellite Service* (Geneva, 1983)

NOTE – These last two documents are available from the International Telecommunications Union (ITU).

(*Continued from second cover*)

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 61079-1 : 1992 Methods of measurement on receivers for satellite broadcast transmissions in the 12 GHz band — Part 1: Radio-frequency measurements on outdoor units	IS 13986 (Part 1) : 1994 Methods of measurement on receivers for satellite broadcast transmissions in the 12 GHz band: Part 1 Radio frequency measurements on outdoor units	Identical

Only the English language text has been retained while adopting it in this Indian Standard, and as such the page numbers given here are not the same as in the IEC Standard.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Bureau of Indian Standards

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